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TECHNICAL MEMORANDUM

U.S. NAVAL APPLIED SCIENCE LABORATORY
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EFFECT OF EMBRITTLED 110-18 WELD METAL

on the

FATIGUE LIFE OF HY-80 STEEL BUTT WELDMENTS

Lab. Project 9300-1, Technical Memorandum 2

SR 007-01-01, Task 0856

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MATERIAL SCIENCE DIVISION

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Ref: (a) BUSHIPS ltr R 007-01-01 Ser 634B-1311 of 24 Oct 1962
(b) MATLAB NAVSHIPYDNYK Report L.P. 6160-2, Progress Report 3 of 17 Jul 1961
(c) BUSHIPS ltr R 007-01-01 Ser 634B-634 of 22 Aug 1963

Fig: (1) Sketch showing distribution of major cracks and location of macrosections.
(2) Rato of Crack Propagation under Fatigue Loading
(3) Relative Fatigue Lives - Sound and Embrittled Butts
(4-6) Photo Nos. L19624-1,2 Macrosections Showing Relationship between Fatigue and Embrittlement Cracks and orientation of the macrosections. (Figure 5 - Sketch)

1. As part of the High Strength Steel Program, the U.S. Naval Applied Science Laboratory has been investigating the effects of welding on the fatigue properties of HY-80 steels. In accordance with reference (a), the effects of "embrittled weld metal" on the fatigue life of HY-80 steel weldments were explored and the results are reported herein.

2. Two HY-80 butt-welded assemblies (32" x 29 1/2" x 1 1/2") were fabricated with MIL-110-18 type electrodes, employing a 60° double-vee joint, and welded in accordance with prevailing instructions for joining HY-80 steels.

3. An "embrittled weld-metal-layer" was intentionally deposited 3/8" below one surface for each butt-welded assembly, and ultimately subjected to low cycle, 0 to tension fatigue loading.

4. Conditions for obtaining these embrittled weld metal deposits are listed below:

a. Electrode Treatment:

(1) MIL-110-18 electrodes were exposed to an atmosphere of 95% relative humidity at 80°F for 5 days.

(2) These electrodes were then subjected to an atmosphere of 50% relative humidity, at 80°F for 24 hours.

b. Welding Procedure:

(1) The embrittled weld metal layers were obtained by employing electrodes treated as noted in paragraph 4a above, and welding at an interpass temperature of 40°F.

(2) All other weld layers were deposited in accordance with current accepted practice for HY-80 steels.

5. The selection of severity and location of the embrittled weld metal layers were influenced by tho following factors:

a. Attempts to introduco appreciably greater amounts of embrittled weld metal, resulted in gross cracking of the welded assembly.

b. It was assumed that, during construction or in service, a condition of weld embrittlement at the surface would ultimately crack and be detected by routine visual or magnetic particle inspection. Therefore, the Laboratory confined the embrittled weld metal layer and associated cracking to a portion internally located within the weldment, completely surrounded by sound weld metal, and likely to be undetected in the course of routine visual and and magnetic particle surveillance inspections.

6. Each of tho two weldments were fatigue tested in accordance with procedures described in reference (b) at a stress level of 50,000 psi.

7. Prior to fatigue testing, each woldment was examined by magnetic particle and X-Ray methods. The location, size, direction and extent of major cracks, associated with tho embrittled weld metal, are indicated in Figure 1.

8. Figure 2 shows the initiation and progression of surface crack lengths which formed in the course of fatigue testing.

A comparison of results on the embrittled weldments and sound weldments is shown graphically in Figure 3. As indicated therein, the fatigue lives of the two embrittled assemblies approximated those which would be expected for sound weldments on the basis of results reported in reference (b).

9. As indicated in Figure 1, tho cracks associated with the embrittled weld layer prior to fatigue testing, wero transverse. Accordingly, crack depth and spacing are evident in the longitudinal macrosection (LL) shown in Figure 4. Tho fatigue crack is not shown in this view. Figure 5 indicates the orientation of macrosections selected from specimen LS PBC-2 after fatigue testing. Photographs of these macrosections are shown in Figure 6. The macrosections taken at a 45° angle (B-B, C-C, D-D) illustrate the relationship between embrittlement and fatigue type cracks. Since the embrittlement cracks were transverse, the parallel transverse macrosection (A-A) only exhibits the fatigue crack.

10. As indicated in Figure 6 the fatigue cracks initiated at the heat affected zone (toe of weld), propagated through the base plate, but did not approach any embrittled weld metal deposit.

11. It should be noted that the cracks associated with the embrittled weld deposit were transverse to the weld and parallel to the imposed

fatigue load. It is believed that if the direction of stress were parallel to the weld (perpendicular to the direction of cracking), degradation would be evident. Additional work is required for a quantitative estimation of this degradation. The deleterious effects of this type of weld embrittlement and associated cracking would probably also be apparent under impact type loading (Explosion Bulge).

12. In accordance with reference (e) further studies of embrittled weld metal effects will not be scheduled for Fiscal Year 64. The next phase of work will be concerned with the effects of mechanical peening on fatigue properties of HY-80 tee joints. It is estimated that this phase will be reported in approximately 3 months from date.

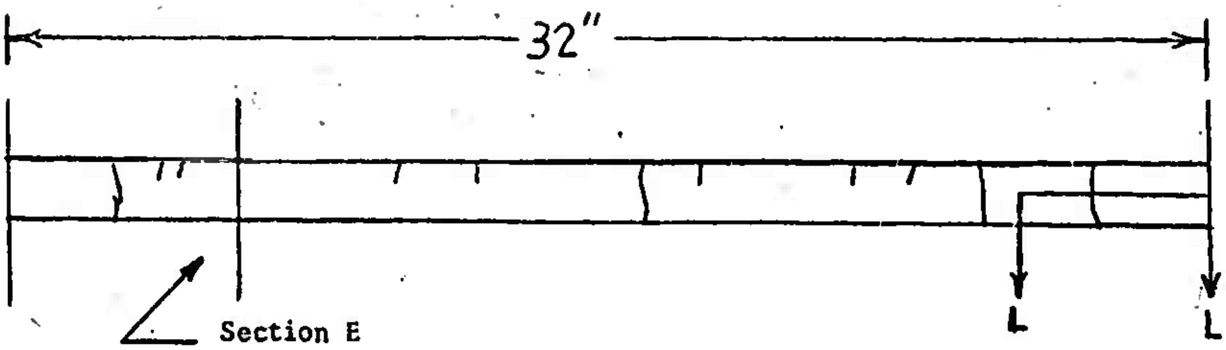


Plate No. L5PBC-2

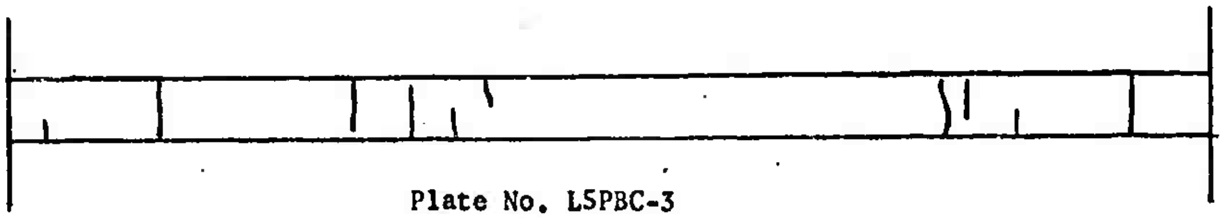


Plate No. L5PBC-3

Fig. 1 - Location of Major Cracks Prior to Fatigue Testing

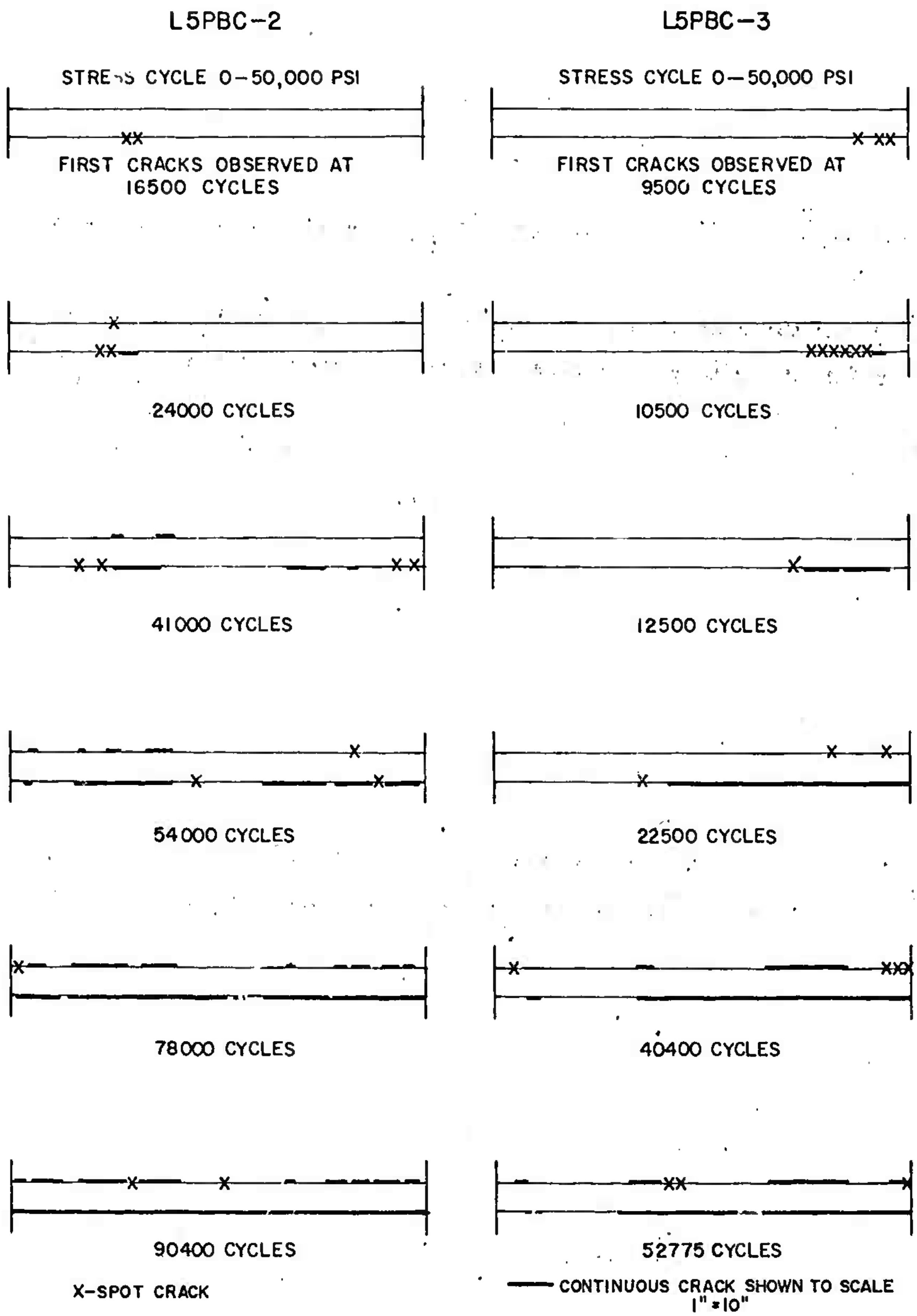
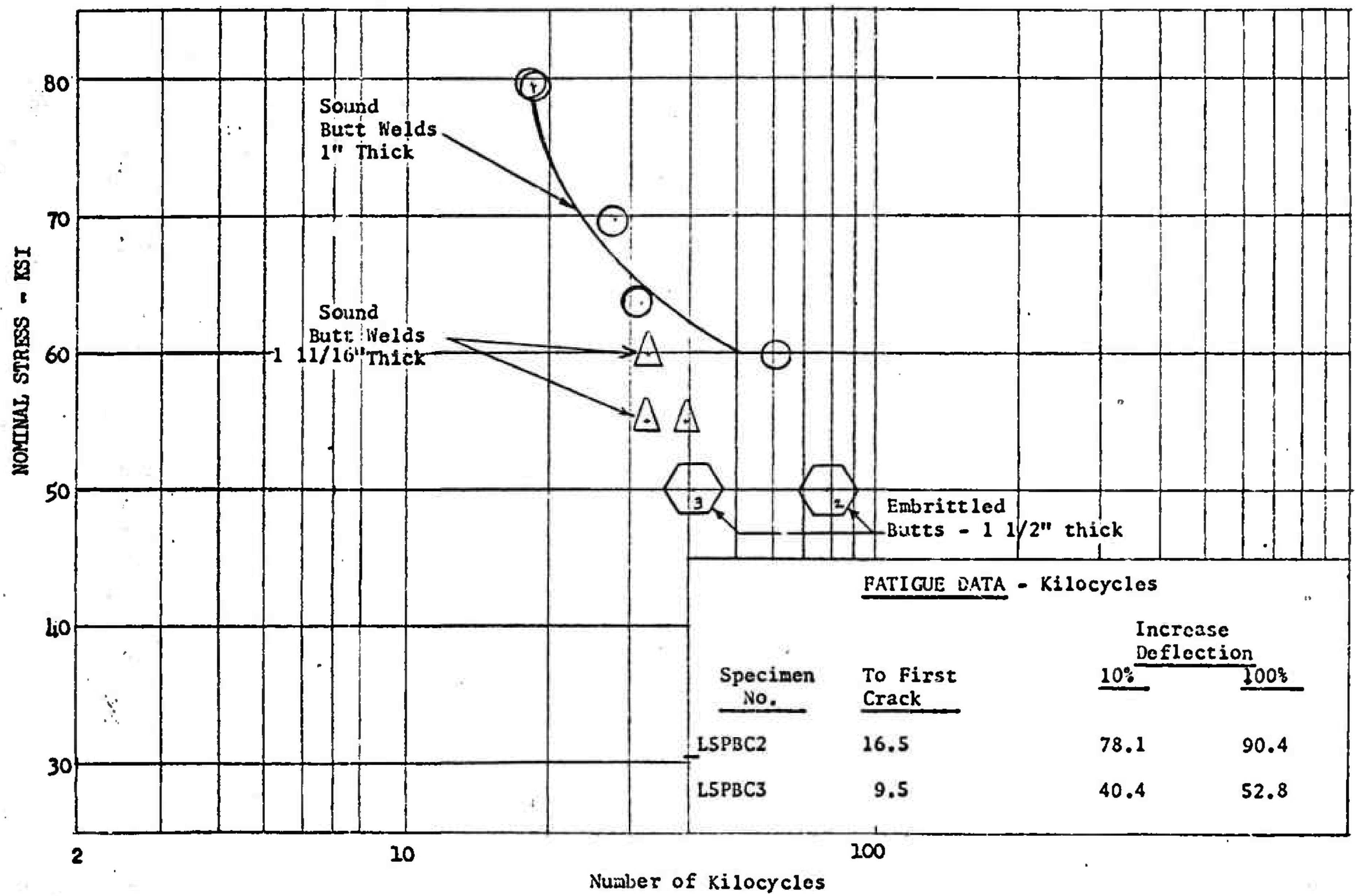
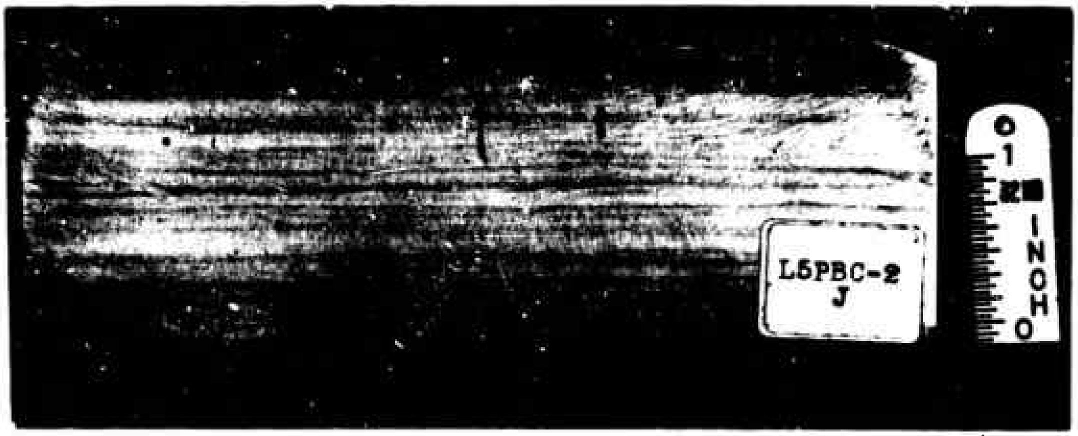


Fig. 2 - CRACK PROGRESS IN BUTT WELDED PLATE TYPE SPECIMENS L5PBC-2 AND L5PBC-3



Specimen No.	To First Crack	Increase Deflection 10%	100%
LSPBC2	16.5	78.1	90.4
LSPBC3	9.5	40.4	52.8

Fig. 3 - Fatigue Life of HY-80 Butt Weldments to 10% Increase in Deflection



Longitudinal Section L-L of Fig. (1)

Fig. (4) Macrograph of Embrittled Butt Weldment L5PBC-2
After Fatigue Testing

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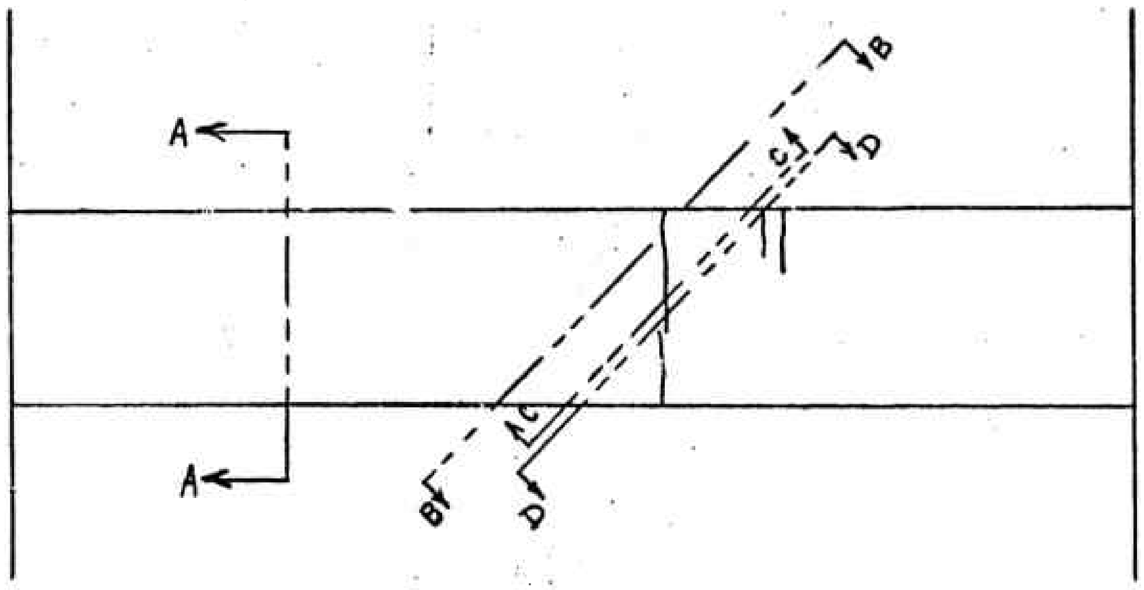
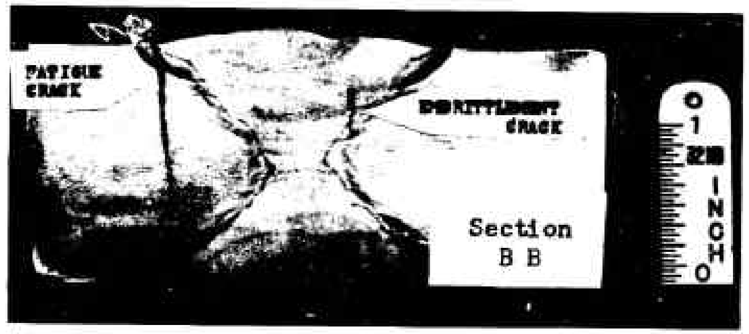


Enlarged View of Section E of Fig (1)

Fig. 5 - Location of 45° Transverse Macro Section Taken From Embrittled Weldment After Fatigue Testing



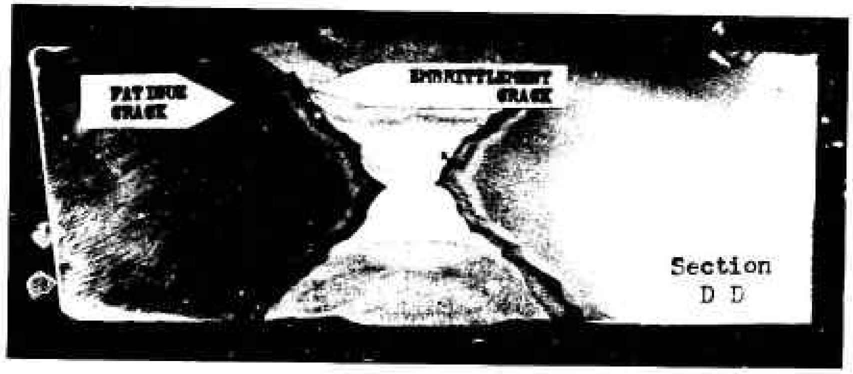


Fig.(6)

Macrographs of Butt-Weldment L5PBC-2
Showing Embrittlement and Fatigue Type Cracks
(See Fig.(5))

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